MANUFACTURE OF DEFORMABLE MIRROR DEVICE

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Abstract

PROBLEM TO BE SOLVED: To manufacture a deformable mirror device which is free of a structure cutting off light and uses a piezoelectric thin film. SOLUTION: A mirror substrate which has a common electrode film 108, the piezoelectric film 107, and a pixel electrode film 106 formed on Si substrate 300 is stuck on a thin-film transistor 102 formed on a glass substrate 101 across bumps 105. Then Si substrate 300 is all etched away.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the manufacture method of the mirror device which can be transformed which can be used as a space optical modulator.
[0002]

[**Description of the Prior Art**] In the mirror membrane structure which consists of the structure which pinched the piezo-electric thin film by the electrode thin film conventionally As the manufacture method of the mirror device which modulates the light which impresses voltage to a

piezo-electric thin film by active elements, such as TFT, is made to transform a mirror membrane structure, and carries out incidence to a mirror membrane structure by deformation of the mirror membrane structure and which can be transformed The method of sticking the mirror substrate in which the mirror membrane structure is formed, and the active element substrate of each other in which the active element is formed was devised.

[0003] A mirror substrate arranges the mirror element used as a pixel which can be deformed to substrates, such as silicon, in the shape of a 2-dimensional array, and is formed in them. Although a mirror membrane structure is formed on the surface of a silicon substrate, in order to make deformation of a mirror membrane structure possible, it **********s and, as for the silicon substrate of the portion corresponding to a deformation field, an aperture (substrate removal section) is formed. An active element substrate forms TFT on the substrate which consists of glass, a quartz, etc., and is manufactured. Both substrates make the mirror element which can be deformed, and TFT correspond for every pixel, and are stuck. In order to make the mirror element which can deform deform, it is necessary to supply the driver voltage generated by TFT to a piezo-electric thin film. For this reason, the field in which the mirror membrane structure was formed among mirror substrates is made to counter TFT, and both substrates are stuck through the bump who connects electrically the electrode of TFT, and the electrode thin film which constitutes a mirror membrane structure.

[0004] According to the above-mentioned composition, in this mirror device that can be transformed, when carrying out incidence of the lighting light (incident light) from a mirror substrate side, incidence will be carried out from the aperture (substrate removal section) prepared in the silicon substrate, it will be reflected by the mirror membrane structure, and this incident light will be again injected from an aperture.

[0005]

[Problem(s) to be Solved by the Invention] However, in the above-mentioned conventional mirror device which can be transformed, since the aperture (substrate removal section) formed in the silicon substrate interrupted light or became the cause of producing unnecessary reflection, there was a trouble of bringing about the fall of the contrast of light modulation. That is, in the Prior art, incidence of light and injection were performed through the aperture formed in the silicon substrate. A certain amount of thickness (100 micrometers - 200 micrometers) is required for a silicon substrate so that the handling in a manufacturing process may become easy. However, if the size of 1 pixel, i.e., one mirror element which can be deformed, is made small, compared with opening of an aperture, the depth of an aperture will become deep. For example, if opening of 100 micrometers and an aperture is set to 50 micrometers for the thickness of a silicon substrate, the depth of an aperture will also become the double precision of opening of an aperture.

[0006] The contrast of light modulation aims [the use efficiency of light] high at offering the mirror device in which high deformation is possible by this invention's solving such a trouble, and removing all, after sticking the heat-resistant substrate in which the mirror membrane structure was formed with an active element substrate.

[0007]

[Means for Solving the Problem] The manufacture method of the mirror device according to claim 1 which can be transformed The mirror stratification process which carries out a laminating to the order of the 1st electrode thin film layer, the piezo-electric thin film layer which has piezoelectric, and the 2nd electrode thin film layer on a heat-resistant substrate and which can be transformed, In the active element substrate in which the array of the pixel pattern formation process which **********s the electrode thin film layer of the above 2nd and the aforementioned piezo-electric thin film layer in the mirror element configuration used as a pixel where it became independent, and the active element corresponding to the aforementioned pixel is formed In order to connect electrically the bump formation process which forms the bump for taking the aforementioned mirror element and electric connection for every aforementioned active element, and each aforementioned mirror element and each aforementioned active element corresponding to it It is characterized by having the substrate lamination process which sticks the aforementioned heat-resistant substrate and the aforementioned active element substrate so that the electrode thin film layer of the above 2nd may counter with the aforementioned bump, and the substrate removal process of leaving the aforementioned mirror layer which can be deformed and removing the aforementioned heat-resistant substrate.
[0008] Since there is no structure of interrupting light or producing unnecessary reflection in the optical incidence side of a mirror element according to the above-mentioned composition, it has the effect that an incident light can be modulated efficiently.
[0009] The manufacture method of the mirror device according to claim 2 which can be transformed is characterized by the aforementioned heat-resistant substrate being a silicon substrate in the manufacture method of the mirror device according to claim 1 which can be transformed.
[0010] According to the above-mentioned composition, it has the effect that the aforementioned heat-resistant substrate is removable by etching.
[0011] The manufacture method of the mirror device according to claim 3 which can be transformed is characterized by the aforementioned heat-resistant substrate being a quartz substrate in the manufacture method of the mirror device according to claim 1 which can be transformed.
[0012] According to the above-mentioned composition, it has the effect that the aforementioned heat-resistant substrate is removable by etching.
[0013] The manufacture method of the mirror device according to claim 4 which can be transformed is characterized by the etching method used in the aforementioned substrate removal process being reactive ion etching in the manufacture method of a claim 1 or the mirror device of three given in any 1 term which can be transformed.
[0014] According to the above-mentioned composition, it has the effect that a heat-resistant substrate can be alternatively etched to other members.
[0015]

[Embodiments of the Invention] It explains referring to the drawing of appending of the manufacture method of the mirror device which starts the gestalt of suitable operation of this invention hereafter and which can be transformed.

[0016] (1st operation gestalt) Drawing 1 and drawing 2 are some cross sections of the mirror device 100 which can be transformed by which **** manufacture is carried out at the manufacture method of the mirror device of this invention which can be transformed.
[0017] TFT (it omits Following TFT) 102 is formed on the glass substrate 101 640 element x480 element in the shape of a two dimensional array. After plating gold to the drain electrode 103 of TFT102, the bump 105 who **********ed to the desired pattern is formed. A bump's 105 height is about 20 micrometers, and while pinches a piezoelectric film 107 and it is connected to the electrode thin film 106, i.e., a pixel electrode layer. The mirror membrane structure consists of the laminated structure of the common electrode layer 108, a piezoelectric film 107, and the pixel electrode layer 106. The transparent insulator layer 109 is formed in the front face of the common electrode layer 108. The thickness of the common electrode layer 108, a piezoelectric film 107, and the pixel electrode layer 106 is about 1 micrometer in all.
[0018] It curves so that it may be referred to by mirror element 111A which a piezoelectric film 107 will transform if voltage is impressed to the pixel electrode layer 106 of a mirror membrane structure by TFT102, and drawing 1 is transforming. A mirror membrane structure is almost flat so that it may be referred to on the other hand by mirror element 111B which is not deforming when voltage is not impressed by TFT102.
[0019] The common electrode layer 108 is a common electrode to each pixel, as shown in drawing 2 , it connects with the common electrode-terminal film 200 through a bump 201, and the potential of the common electrode layer 108 is decided by potential of the common electrode-terminal film 200.
[0020] Then, the manufacture method of the mirror device which can be transformed is explained using drawing 3 - drawing 5 .
[0021] First, the manufacture method of a mirror membrane structure is explained using drawing 3 . On the silicon (it omits Following Si) substrate 300, the thermal oxidation film of Si used as the transparent insulator layer 109 is formed. Metal thin films, such as platinum (it omits Following Pt) which serves as the common electrode layer 108 on it, are formed. The PZT (it omits Following PZT) film which turns into a piezoelectric film 107 on it is formed. Next, heat annealing is performed in order to take out the property of a piezoelectric film. Since a heat annealing process is required, as a substrate, a heat-resistant substrate is needed. Next, metal thin films, such as Pt used as the pixel electrode layer 106, are formed. Then, in order to form the independent mirror element 111 corresponding to the pixel of a space optical modulator, it **********s in the pixel configuration of a request of the pixel electrode layer 106 and a piezoelectric film 102.
[0022] In drawing 3 , the configuration of a mirror element is circular, therefore the field which deforms a mirror element is circular. If voltage is impressed to a piezoelectric film, a mirror element will deform in the shape of the spherical surface (curve). The bump 105 for taking the electric connection with TFT is connected with the pixel electrode layer 106 with the electrode pad 301. In order to make a deformation field as circular as possible, it is a narrow pattern between the electrode pad 301 and the deformation field of a mirror element. In addition, since one TFT is connected corresponding to one mirror element, if the array of TFT is 640x480, it will become the 640x480 number of the arrays of a mirror element.
[0023] The connection method of a TFT element and a mirror element is shown in drawing 4 .

The Si substrate 300 explained by drawing 3 turns to the direction of TFT102 the field in which the pixel electrode layer 106, the piezoelectric film 107, and the common electrode layer 108 are formed, and thermocompression bonding is carried out to the bump 105 of a TFT element substrate.

[0024] Some cross sections of the mirror device in this stage which can be transformed are shown in drawing 5 (a).

[0025] Then, if Si substrate is all removed by the reactive-ion-etching method using the gas of the fluorine system which can etch Si alternatively, the mirror membrane structure supported by the bump 105 as shown in drawing 5 (b) will be formed. In addition, in case Si substrate is **********ed, you may cover the portion into which the substrate in which TFT is formed does not ********** by the resin etc.

[0026] The manufacture method formed in a quartz substrate can be considered instead of a transistor forming a mirror membrane structure in Si substrate instead of the TFT element formed on the glass substrate as a modification of the above manufacture methods, using Si transistor formed in the front face of Si substrate as an active element. In this case, in order to make deformation of a mirror membrane structure possible, in a final process, reactive ion etching using the gas of the fluorine system which can etch a quartz alternatively will all remove the quartz substrate in which the mirror membrane structure is formed. Also at this time, you may cover the portion which does not ********** by the resin etc.

[0027] The example which uses the mirror device which was manufactured at the above processes, and which can be transformed as a space optical modulator is shown in drawing 6 . Drawing 6 is some (three elements) cross sections of a space optical modulator. The shading dot 611 and the micro-lens element 601 are arranged to each mirror element at the coaxis. The shading dot 611 consists of material which absorbs light, on the transparent substrate 612, is arranged on a two dimensional array and constitutes the shading dot array 610. The micro-lens element 601 is also arranged in the shape of a two dimensional array, and constitutes the micro-lens array 600.

[0028] The lighting light 620 is irradiated to the micro-lens array 600. As a lighting light 620, a parallel ray is desirable. The lighting light 620 is condensed with the micro-lens element 601. In mirror element 111B which is not deforming, if the shading dot 611 is arranged at the focus of the micro-lens element 601, it will be shaded by the shading dot 611 and lighting light will not return to the direction of a micro lens. On the other hand, if the focal distance of a micro-lens element is decided that the center of curvature at the time of making deformation of a mirror membrane structure into the spherical surface in mirror element 111A which is deforming, and the focus of the micro-lens element 601 are mostly in agreement, the light reflected by mirror element 111A which is deforming will return to a micro-lens element again. Each other arrangement is decided that the micro-lens array 600, the shading dot array 610, and the mirror membrane structure of center of curvature of the shading dot 611 and a deformation mirror correspond with the focus of the micro-lens element 601 mostly. The light reflected by the mirror membrane structure as mentioned above can be modulated.

[0029] In addition, in order to raise the reflection factor of the light by the mirror membrane structure, it is desirable to form the thin film of material with high reflection factors, such as aluminum (it omits Following aluminum), in the front face of the transparent insulator layer 109.

Under the present circumstances, in order to protect the front face of aluminum, you may form the protection thin film which consists of a transparent material. In addition, since the transparent insulator layer 109 is optically unnecessary, it may be removed and may form aluminum thin film layer in the front face of the common electrode layer 108.
[0030] Since the mirror device which was manufactured by the manufacture method of this invention and which can be transformed does not have the structure of interrupting light or producing unnecessary reflection in the optical incidence side of a mirror membrane structure, it has the effect that an incident light can be modulated efficiently.
[0031] The cross section of the main optical system of the projected type display using the space optical modulator shown in drawing 6 is shown in drawing 7 .
[0032] The light emitted from the light sources 701, such as a metal halide lamp, is changed into a good light of parallelism by the reflector 702 which is a parabolic mirror, and it is made to reflect in the direction of a space optical modulator by the beam splitter 703. As drawing 6 explained, it is shaded by the shading dot 611 and the light reflected by mirror element 111B which is not deforming does not go to the direction of a projection lens. The light reflected on the other hand by mirror element 111A which is deforming passes the circumference of the shading dot 611, and reaches to the projection lens 704 through the micro-lens array 600 and a beam splitter 703, and image formation is carried out to a screen 705. Thus, the light reflected with the mirror element which is deforming reaches a screen, and forms a picture.
[0033] Although the projected type display which used one space optical modulator was explained here, the application to the display which projects a color picture using two or more space optical modulators, the display which observes the virtual image to which the picture generated by the space optical modulator through the lens was expanded is possible for the space optical modulator equipped with the mirror device which was manufactured by the manufacture method of this invention and which can be transformed.
[0034] As mentioned above, the manufacture method of the mirror device of this invention which can be transformed, and the manufacture method explained with the above-mentioned operation gestalt although the application of the mirror device which can be transformed was explained can be widely applied to the manufacture method of all removing the substrate supporting the deformation mirror membrane structure, without being limited to the operation gestalt.
[0035]

[Effect of the Invention] Since the mirror device which was manufactured by the manufacture method of this invention of all removing the substrate supporting the mirror membrane structure described above like and which can be transformed does not have the structure of interrupting light or producing unnecessary reflection in the optical incidence side of a mirror membrane structure, it has the effect that the high space optical modulator of efficiency for light utilization can be offered.

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] The mirror layer formation-on thermal-resistance substrate characterized by providing the following process which can be transformed [which carries out a laminating to the order of the 1st electrode thin film layer, the piezo-electric thin film layer which has piezoelectric, and the 2nd electrode thin film layer], The active element substrate in which the array of the pixel pattern formation process which **********s the electrode thin film layer of the above 2nd and the aforementioned piezo-electric thin film layer in the mirror element configuration used as a pixel where it became independent, and the active element corresponding to the aforementioned pixel is formed. The bump formation process which forms the bump for taking the aforementioned mirror element and electric connection for every aforementioned active element. The substrate lamination process which sticks the aforementioned heat-resistant substrate and the aforementioned active element substrate so that the electrode thin film layer of the above 2nd may counter with the aforementioned bump in order to connect electrically each aforementioned mirror element and each aforementioned active element corresponding to it, and the substrate removal process of leaving the aforementioned mirror layer which can be deformed and removing the aforementioned heat-resistant substrate.
[Claim 2] The manufacture method of the mirror device according to claim 1 which is characterized by the aforementioned heat-resistant substrate being a silicon substrate and which can be transformed.
[Claim 3] The manufacture method of the mirror device according to claim 1 which is characterized by the aforementioned heat-resistant substrate being a quartz substrate and which can be transformed.
[Claim 4] The manufacture method of the mirror device given in the claim 1 characterized by the etching method used in the aforementioned substrate removal process being reactive ion etching, or any 1 term of 3 which can be transformed.

[Translation done.]

SPATIAL OPTICAL MODULATOR AND PROJECTION TYPE DISPLAY DEVICE

SPATIAL OPTICAL MODULATOR AND PROJECTION TYPE DISPLAY DEVICE

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Abstract

PROBLEM TO BE SOLVED: To provide the spatial optical modulator equipped with a deformable mirror device which is free of the shielding and scattering of light by a structure to support a deformable mirror element.
SOLUTION: On an Si substrate 112, a transparent insulating film 109, a common electrode film 108, a piezoelectric film 107, and a pixel electrode film 106 are laminated to form mirror elements in a two-dimensional array. Then substrate-removed parts 113 are formed by etching the Si substrate 112 to enable the mirror elements to deform. The mirror elements are connected to thin-film transistors 102 formed on a glass substrate 101 through bumps 105. Illumination light irradiates the mirror elements through the glass substrate 101.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the structure of the mirror device which can be used as a space optical modulator and which can be transformed, and

the structure of the projected type display using it.
[0002]

[Description of the Prior Art] In the mirror membrane structure which consists of the structure which pinched the piezo-electric thin film by the electrode thin film, impressed voltage to the piezo-electric thin film by active elements, such as TFT, the mirror membrane structure was made to transform conventionally, and the structure which stuck the mirror substrate in which the mirror membrane structure is formed, and the active element substrate of each other in which the active element is formed as a mirror device which modulates the light which carries out incidence to a mirror membrane structure by deformation of the mirror membrane structure, and which can be transformed was devised.
[0003] This structure is explained using drawing 7 . Drawing 7 is the cross section of some mirror elements which constitute the mirror device which can be transformed and which can be deformed.
[0004] On the silicon (Si) substrate 112, the mirror elements 111A and 111B which can be deformed are arranged in the shape of a 2-dimensional array, and a mirror substrate is constituted. Although the laminating of the transparent insulator layer 109, the common electrode layer 108, a piezoelectric film 107, and the pixel electrode layer 106 is carried out to the front face of a silicon substrate 112 and a mirror membrane structure is formed in it, in order to make deformation of a mirror membrane structure possible, it **********s and, as for the silicon substrate of the portion corresponding to a deformation field, the substrate removal section 113 is formed.
[0005] TFT 102 is formed on a glass substrate 101, and an active element substrate is constituted.
[0006] A mirror substrate and an active element substrate make the mirror element which can be deformed, and TFT correspond for every pixel, and are stuck. In order to make the mirror element which can deform deform, it is necessary to supply the driver voltage generated by TFT to a piezoelectric film 107. For this reason, the mirror membrane structure formed in the mirror substrate is made to counter TFT, and both substrates are stuck through the bump 105 who connects electrically the drain electrode 103 of TFT, and the pixel electrode layer 106 which constitutes a mirror membrane structure.
[0007] When carrying out incidence of the lighting light 701 from a mirror substrate side in the mirror device of such structure which can be transformed, incidence of this lighting light will be carried out from the substrate removal section 113 prepared in the silicon substrate, and the reflected light 702 reflected by the mirror membrane structure will be again injected from the substrate removal section.
[0008]

[Problem(s) to be Solved by the Invention] However, in the above-mentioned conventional mirror device which can be transformed, since the substrate removal section formed in the silicon substrate interrupted light or became the cause of producing unnecessary reflection, there was a trouble of bringing about the fall of the contrast of light modulation.
[0009] A certain amount of thickness (100 micrometers - 200 micrometers) is required for a

silicon substrate so that the handling in a manufacturing process may become easy. However, if the size of 1 pixel, i.e., one mirror element which can be deformed, is made small, compared with opening of the substrate removal section, the depth will become deep. For example, if opening of 100 micrometers and the substrate removal section is set to 50 micrometers for the thickness of a silicon substrate, the depth will also become the double precision of opening.
[0010] By this invention's solving such a trouble, making the transistor which impresses voltage to a mirror membrane structure into the TFT formed on a transparent substrate, and carrying out incidence of the lighting light to a mirror membrane structure through this transparent substrate, cover of the light by the silicon substrate supporting the mirror membrane structure is lost, and it aims at raising the contrast of light modulation.
[0011]

[**Means for Solving the Problem**] By a space optical modulator according to claim 1 consisting of a piezo-electric thin film and the electrode thin film which pinches this piezo-electric thin film, and impressing voltage to the aforementioned piezo-electric thin film, the array of the mirror element which can deform in the shape of a curved surface, In the space optical modulator equipped with the array of the active element formed on the active element substrate which consists of a transparent substrate, and the structure of connecting each of the aforementioned active element electrically corresponding to each of the aforementioned mirror element, it is characterized by making lighting light irradiate the aforementioned mirror element through the aforementioned active element substrate.
[0012] Since lighting light can be irradiated from how which the structure which supports a mirror element twists at a mirror element according to the above-mentioned composition, it has the effect which neither cover, nor unnecessary dispersion or unnecessary reflection of light produces that the bright space optical modulator where contrast is high can be constituted.
[0013] A space optical modulator according to claim 2 is characterized by arranging the lens array which changes from the array of the lens element corresponding to each of the aforementioned mirror element to the incidence side of the aforementioned lighting light of the aforementioned active element substrate, and arranging the focus by the side of the aforementioned active element substrate of the aforementioned lens element in the position of the paraxial center of curvature at the time of deformation of the aforementioned mirror element, or its near in a space optical modulator according to claim 1.
[0014] According to the above-mentioned composition, since lighting light can be centralized on the deformation field of a mirror element, it has the effect that the light which illuminates the non-variant part which does not contribute to the modulation of light can be suppressed.
[0015] It is characterized by, as for a space optical modulator according to claim 3, arranging the array of a pinhole in a space optical modulator according to claim 2 corresponding to each of the aforementioned mirror element, and arranging the aforementioned pinhole in the position of the paraxial center of curvature at the time of deformation of each aforementioned corresponding mirror element, or its near.
[0016] According to the above-mentioned composition, it has the effect that the contrast of the modulation of light can be raised.
[0017] projected type display according to claim 4 -- the light from a space optical modulator,

the light source, and this light source given in a claim 1 or any 1 term of 3 -- abbreviation -- it is characterized by having the lighting optical system which changes into an parallel light and illuminates the aforementioned space optical modulator, and the optical system which projects the image modulated and generated by the aforementioned space optical modulator
[0018] According to the above-mentioned composition, since there is little cover of the light in a space optical modulator, unnecessary reflection, or dispersion, it has the effect that the high projected type display of contrast can be constituted brightly.
[0019] a projected type liquid crystal display according to claim 5 -- the light from a space optical modulator according to claim 2, the light source, and this light source -- abbreviation -- it is characterized by having the lighting optical system which changes into an parallel light and illuminates the aforementioned space optical modulator, the lens system arranged between the aforementioned lens array and a projection lens, and the pinhole arranged the position of the focus of this lens system, or near the focus
[0020] According to the above-mentioned composition, it has the effect that the high projected type display of contrast can be constituted from easy optical system.
[0021]

[Embodiments of the Invention] It explains referring to the drawing of appending of the space optical modulator and projected type display which are hereafter applied to the form of suitable operation of this invention.
[0022] (1st operation form) The structure of the mirror device which is the element which constitutes the space optical modulator of this invention using drawing 1 , drawing 2 , and drawing 3 and which can be transformed is explained first. Drawing 1 is some cross sections of the mirror device which can be transformed. Drawing 2 is the perspective diagram and cross section showing the array of the mirror element which is an element which constitutes the mirror device which can be transformed. Drawing 3 is a perspective diagram for explaining junction in a mirror element and the array of the TFT for driving it.
[0023] TFT 102 is formed on the glass substrate 101 640 element x480 element in the shape of a two dimensional array. After plating gold to the drain electrode 103 of TFT 102, the bump 105 who **********ed to the desired pattern is formed. A bump's 105 height is about 20 micrometers, and while pinches a piezoelectric film 107 and it is connected to the electrode thin film 106, i.e., a pixel electrode layer.
[0024] An air gap (opening) 110 is between the pixel electrode layer 106 and the diaphragm structure on the glass substrate with which TFT 102 is formed.
[0025] The mirror membrane structure consists of the laminated structure of the transparent insulator layer 109, the common electrode layer 108, a piezoelectric film 107, and the pixel electrode layer 106. The thickness of the common electrode layer 108, a piezoelectric film 107, and the pixel electrode layer 106 is about 1 micrometer on the whole.
[0026] If voltage is impressed to the pixel electrode layer 106 of a mirror membrane structure by TFT 102, a piezoelectric film 107 will deform and will curve like mirror element 111A which is deforming. Like mirror element 111B which is not deforming on the other hand when voltage is not impressed by TFT 102, a mirror membrane structure is almost flat.
[0027] The common electrode layer 108 is a common electrode to each pixel.

[0028] Then, the manufacture method of the mirror device which can be transformed is explained using drawing 2 and drawing 3 .
[0029] First, the manufacture method of a mirror membrane structure is explained using drawing 2 . On a silicon substrate 112, the silicon thermal oxidation film used as the transparent insulator layer 109 is formed. Metal thin films, such as platinum (Pt) which serves as the common electrode layer 108 on it, are formed. The PZT (PZT) film which turns into a piezoelectric film 107 on it is formed. Next, heat annealing is performed in order to take out the property of a piezoelectric film. Since a heat annealing process is required, as a substrate, a heat-resistant substrate is needed. Next, metal thin films, such as platinum (Pt) used as the pixel electrode layer 106, are formed. Then, in order to form the independent mirror element 111 corresponding to the pixel of a space optical modulator, it **********s in the pixel configuration of a request of the pixel electrode layer 106 and a piezoelectric film 102.
[0030] The bump 105 for taking the electric connection between TFT and a mirror element is connected with the pixel electrode layer 106 with the electrode pad 201. In order to make a deformation field as circular as possible, it is a narrow pattern between the electrode pad 201 and the deformation field of a mirror element.
[0031] Then, in order to make deformation of a mirror element possible, the silicon substrate in the lower part of a mirror membrane structure is **********ed, and the substrate removal section 113 is formed.
[0032] In drawing 2 , the configuration of a mirror element is circular, therefore the field which deforms a mirror element is circular. If voltage is impressed to a piezoelectric film, a mirror element will deform in the shape of the spherical surface (curve). In addition, since one TFT is connected corresponding to one mirror element, if the array of TFT is 640x480, it will become the 640x480 number of the arrays of a mirror element.
[0033] The connection method of TFT and a mirror element is shown in drawing 3 . The pixel electrode layer 106 which constitutes the mirror element explained by drawing 2 is turned to the direction of TFT 102, and thermocompression bonding of the electrode pad 201 is carried out to the bump 105 of a TFT element substrate.
[0034] The example which uses the mirror device which was manufactured at the above processes, and which can be transformed as a space optical modulator is shown in drawing 4 . Drawing 4 is some (three elements) cross sections of a space optical modulator.
[0035] To each mirror element, a pinhole 411 and the micro-lens element 401 make an optical axis in agreement, and are arranged. A pinhole 411 makes a hole in the shading film 412 formed in the front face of the transparent substrates 413, such as glass, is formed in it, is arranged in the shape of a two dimensional array on the transparent substrate 413, and constitutes the pinhole array 410. The micro-lens element 401 is also arranged in the shape of a two dimensional array, and constitutes the micro-lens array 400.
[0036] A pinhole 411 is arranged in the center of curvature at the time of approximating the deformation configuration of a mirror element by the spherical surface, or its near. Moreover, a pinhole 411 is arranged in the focus of the micro-lens element 401, or its near.
[0037] The lighting light 420 is irradiated to the micro-lens array 400. As a lighting light 420, a parallel ray is desirable. After it is condensed by the pinhole 411 and the lighting light 420 passes a pinhole with the micro-lens element 401, incidence of it is carried out to a mirror element, and

it is reflected. TFT 102 is formed in the position which does not interrupt lighting light.

[0038] Although the light on an optical axis passes a pinhole 411 again among the light reflected by mirror element 111B which is not deforming and the micro-lens element 401 is penetrated, it emits, is shaded by the shading film 412, and other light does not return to the direction of the micro-lens element 401.

[0039] After the light reflected on the other hand by mirror element 111A which is deforming passes a pinhole 411, incidence of it is carried out to the micro-lens element 401, it turns into an almost parallel light, and is injected from the micro-lens element 401.

[0040] When light can be modulated and the mirror device which can be transformed is seen through the micro-lens array 400 by the above principles, the pixel (it corresponds to 111B) which is not deforming is dark, and the pixel (it corresponds to 111A) which is deforming looks bright.

[0041] In addition, in order to raise the reflection factor of the light by the mirror membrane structure, it is desirable to carry out the laminating of the thin films, such as aluminum, to the front face of thin films, such as to make the pixel electrode layer 106 into thin films, such as aluminum with a high reflection factor, or platinum, further.

[0042] Since the mirror device which was manufactured by the manufacture method of this invention and which can be transformed interrupts lighting light or does not have the structure of producing the unnecessary reflected light, it has the effect that an incident light can be modulated efficiently.

[0043] In addition, since light passes along the transparent substrate in which TFT is formed, while being able to raise the use efficiency of light by forming an antireflection film in both sides of the substrate, the unnecessary reflected light to which contrast is reduced can be stopped.

[0044] Although it has left the silicon substrate as structure supporting a mirror element with this operation form, after joining a mirror element and TFT, a silicon substrate may be crossed to the whole surface and may be removed.

[0045] (2nd operation form) The cross section of the main optical system of the projected type display using the space optical modulator explained with the 1st operation form is shown in drawing 5 . In order to make drawing legible, it simplifies sharply and the composition of the mirror device which can be transformed is drawn.

[0046] The light emitted from the light sources 501, such as a metal halide lamp, is changed into a good light of parallelism by the reflector 502 which is a parabolic mirror, and it is made to reflect in the direction of a space optical modulator by the beam splitter 503.

[0047] As the 1st operation form explained, the light reflected by mirror element 111A which is deforming passes a pinhole 411, and reaches to the projection lens 504 through the micro-lens array 400 and a beam splitter 503, and image formation is carried out to a screen 505. Most is shaded by the shading film 412 and the light reflected on the other hand by mirror element 111B which is not deforming does not reach the projection lens 504. Thus, the light reflected with the mirror element which is deforming reaches a screen, and forms a picture.

[0048] (3rd operation form) The space optical modulator explained with the 1st operation form shows the cross section of the main optical system of the projected type display using the space optical modulator of composition of differing to drawing 6 . In order to make drawing legible, it simplifies sharply and the composition of the mirror device which can be transformed is drawn.

[0049] Although the composition in which the focus of a micro-lens element and the center of curvature of the mirror element which can be deformed are carrying out simultaneously coincidence is the same compared with the space optical modulator which explained the space optical modulator used with the projected type display of this operation form with the 1st operation form, the composition of a pinhole differs.
[0050] The single pinhole 601 is arranged in the focus of a lens 600, or its near.
[0051] The light emitted from the light sources 501, such as a metal halide lamp, is changed into a good light of parallelism by the reflector 502 which is a parabolic mirror, and the mirror device 100 which can be transformed is illuminated through the micro-lens array 400.
[0052] After becoming an almost parallel light and penetrating a beam splitter 503 by the micro-lens array 400, it is condensed by the focus with a lens 600, and the light reflected by mirror element 111A which is deforming passes a pinhole 601, and reaches to the projection lens 602, and image formation is carried out to a screen 505. Most cannot pass a pinhole 601 and the light reflected on the other hand by mirror element 111B which is not deforming does not reach the projection lens 602. Thus, only the light reflected with the mirror element which is deforming reaches a screen, and forms a picture.
[0053] As mentioned above, although the 2nd or 3rd operation form explained the projected type display which used one space optical modulator, the application to the display which projects a color picture using two or more space optical modulators, the display which observes the virtual image to which the picture generated by the space optical modulator through the lens was expanded is possible for this invention.
[0054]

[Effect of the Invention] It has the effect that the high space optical modulator of efficiency for light utilization which does not produce cover of the light by the supporting structure or unnecessary reflection can be offered, having the supporting structure which supports a mirror membrane structure by [which were described above] forming an active element on a transparent substrate and irradiating lighting light through the transparent substrate like at the mirror element which can deform.
[0055] Moreover, it has the effect that efficiency for light utilization can offer high projected type display, using the space optical modulator.

[Translation done.]

CLAIMS

[Claim(s)]

[Claim 1] It is the array of the mirror element which can deform in the shape of a curved surface by consisting of a piezo-electric thin film and the electrode thin film which pinches this piezo-electric thin film, and impressing voltage to the aforementioned piezo-electric thin film. The array of the active element formed on the active element substrate which consists of a transparent substrate. Structure of connecting each of the aforementioned active element electrically corresponding to each of the aforementioned mirror element. It is the space optical modulator equipped with the above, and is characterized by making lighting light irradiate the aforementioned mirror element through the aforementioned active element substrate.

[Claim 2] The space optical modulator according to claim 1 characterized by arranging the lens array which changes from the array of the lens element corresponding to each of the aforementioned mirror element to the incidence side of the aforementioned lighting light of the aforementioned active element substrate, and arranging the focus by the side of the aforementioned active element substrate of the aforementioned lens element in the position of the paraxial center of curvature at the time of deformation of the aforementioned mirror element, or its near.

[Claim 3] It is the space optical modulator according to claim 2 characterized by arranging the array of a pinhole corresponding to each of the aforementioned mirror element, and arranging the aforementioned pinhole in the position of the paraxial center of curvature at the time of deformation of each aforementioned corresponding mirror element, or its near.

[Claim 4] the light from a space optical modulator, the light source, and this light source given in a claim 1 or any 1 term of 3 -- abbreviation -- the projected type display characterized by having the lighting optical system which changes into an parallel light and illuminates the aforementioned space optical modulator, and the optical system which projects the image modulated and generated by the aforementioned space optical modulator

[Claim 5] the light from a space optical modulator according to claim 2, the light source, and this light source -- abbreviation -- the projected type display characterized by having the lighting optical system which changes into an parallel light and illuminates the aforementioned space optical modulator, the lens system arranged between the aforementioned lens array and a projection lens, and the pinhole arranged the position of the focus of this lens system, or near the focus

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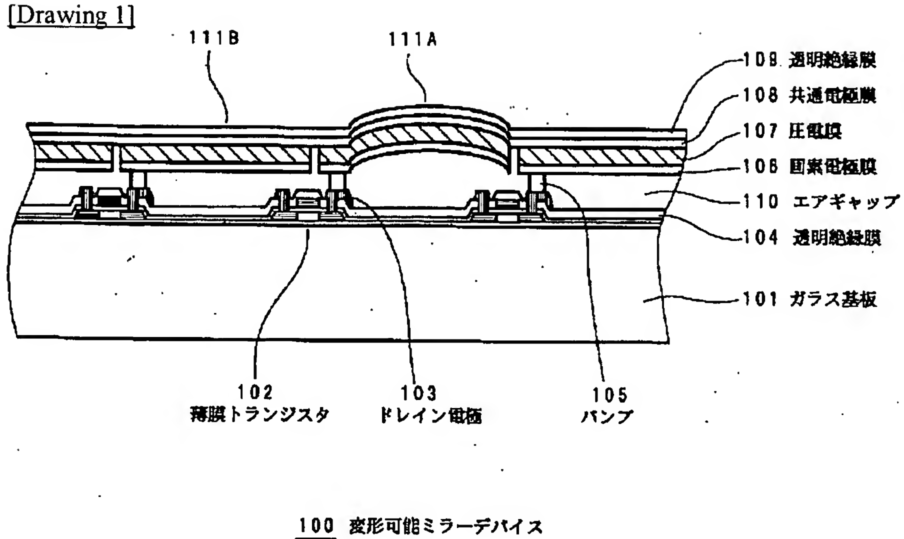
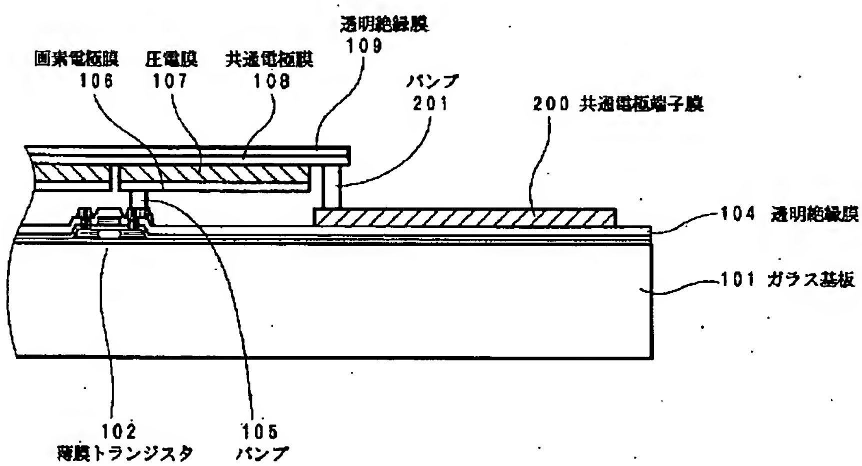
DRAWINGS

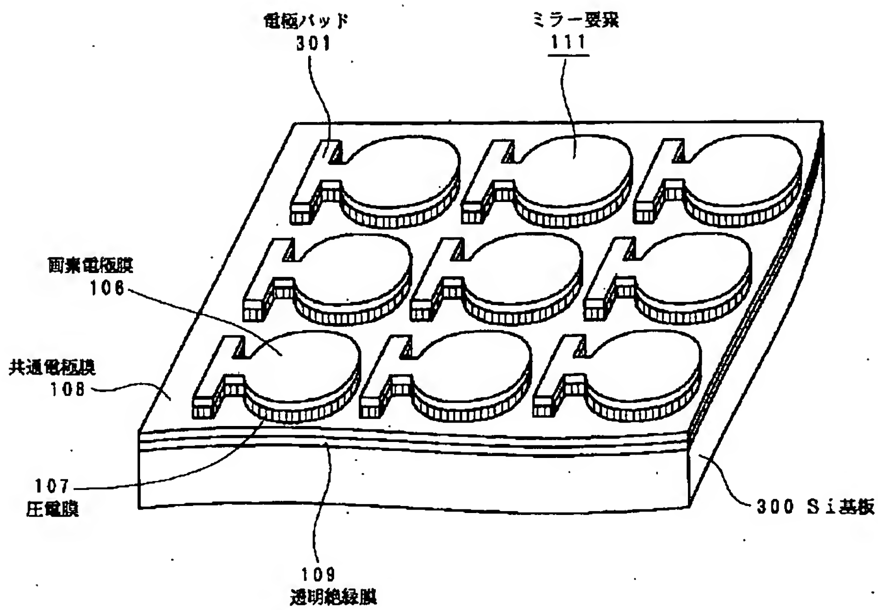
[Drawing 1]



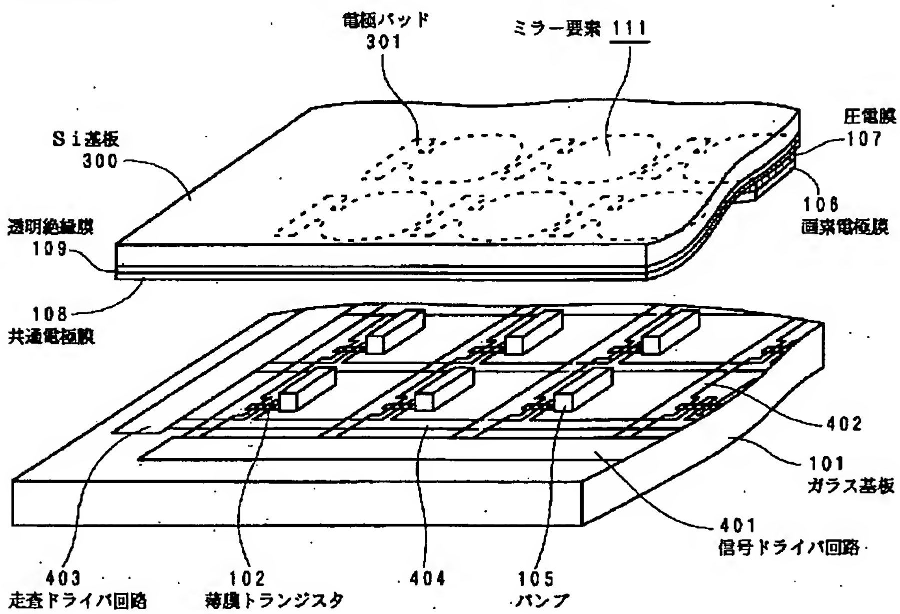
[Drawing 2]



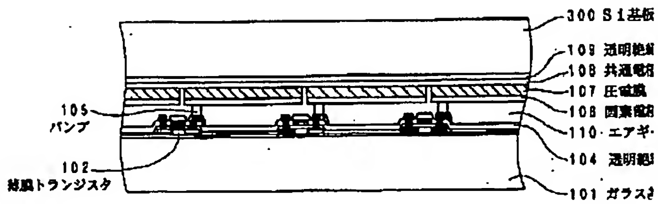
[Drawing 3]



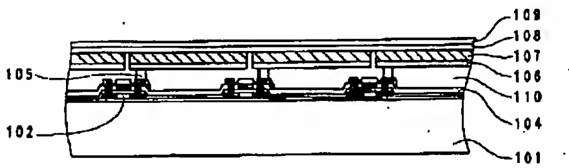
[Drawing 4]



[Drawing 5]

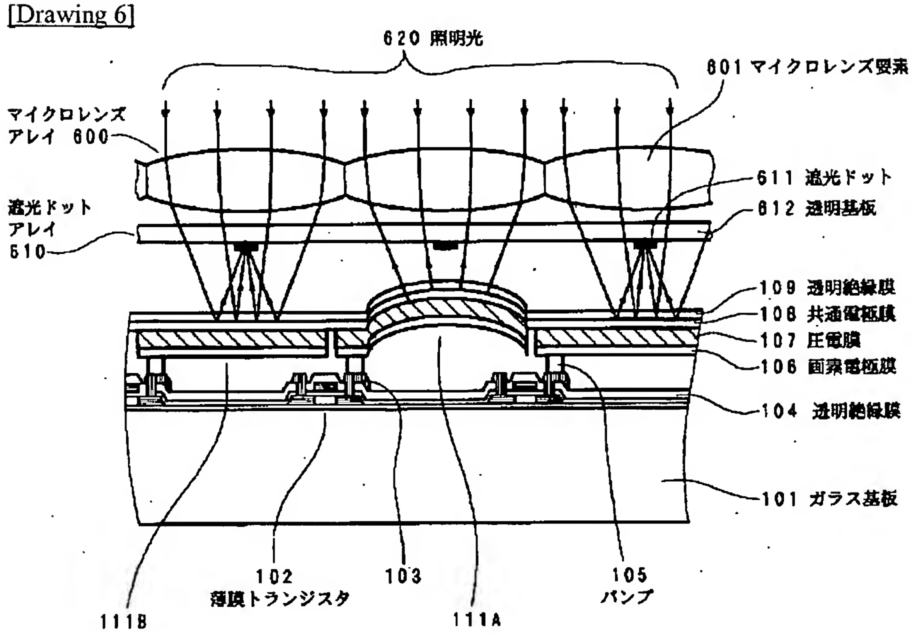


(a)

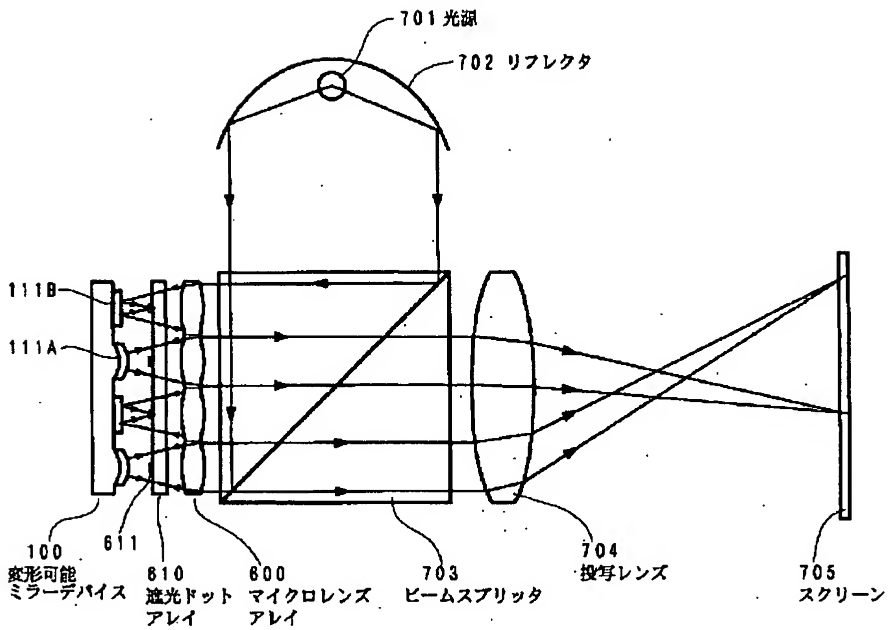


(b)

[Drawing 6]



[Drawing 7]



[Translation done.]

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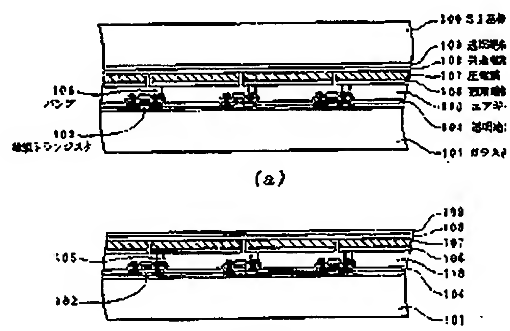
(54)【発明の名称】　変形可能ミラーデバイスの製造方法

(57)【要約】
【課題】　光を遮る構造がない、圧電薄膜を用いた変形可能ミラーデバイスを製造する。
【解決手段】　Ｓｉ基板３００上に共通電極膜１０８、圧電膜１０７および画素電極膜１０６を形成したミラー基板を、ガラス基板１０１上に形成された薄膜トランジスタ１０２に、バンプ１０５を介して貼り合わせる。その後、Ｓｉ基板３００をエッチングですべて除去する。


(a)
(b)

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【特許請求の範囲】

【請求項１】　耐熱性基板上に第１の電極薄膜層、圧電性を有する圧電薄膜層、および第２の電極薄膜層の順に積層する変形可能ミラー層形成工程と、前記第２の電極薄膜層および前記圧電薄膜層を、画素となる独立したミラー要素形状にエッチングする画素パターン形成工程と、前記画素に対応した能動素子の配列が形成されている能動素子基板において、前記能動素子毎に前記ミラー要素と電気的な接続をとるためのバンプを形成するバンプ形成工程と、各前記ミラー要素とそれに対応する各前記能動素子とを電気的に接続するために、前記バンプと前記第２の電極薄膜層が対向するように前記耐熱性基板と前記能動素子基板を貼り合わせる基板貼り合わせ工程と、前記耐熱性基板を、前記変形可能ミラー層を残して除去する基板除去工程と、を備えた変形可能ミラーデバイスの製造方法。

【請求項２】　前記耐熱性基板がシリコン基板であることを特徴とする請求項１に記載の変形可能ミラーデバイスの製造方法。

【請求項３】　前記耐熱性基板が石英基板であることを特徴とする請求項１に記載の変形可能ミラーデバイスの製造方法。

【請求項４】　前記基板除去工程において用いられるエッチング方法が反応性イオンエッチングであることを特徴とする請求項１乃至３のいずれか一項に記載の変形可能ミラーデバイスの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、空間光変調器として用いることができる変形可能ミラーデバイスの製造方法に関する。

【０００２】

【従来の技術】従来、圧電薄膜を電極薄膜で挟持した構造から成るミラー膜構造において、薄膜トランジスタなどの能動素子によって圧電薄膜に電圧を印加してミラー膜構造を変形させ、そのミラー膜構造の変形によってミラー膜構造に入射する光を変調する変形可能ミラーデバイスの製造方法として、ミラー膜構造が形成されているミラー基板と、能動素子が形成されている能動素子基板を互いに貼り合わせる方法が考案されていた。

【０００３】ミラー基板は、シリコンなどの基板に画素となる変形可能ミラー要素を二次元アレイ状に配置して形成される。ミラー膜構造はシリコン基板の表面に形成されるが、ミラー膜構造を変形可能とするために、変形領域に対応する部分のシリコン基板はエッチングされ、窓（基板除去部）が形成される。能動素子基板は、ガラスや石英等から成る基板上に薄膜トランジスタを形成して製造される。両基板は、変形可能ミラー要素と薄膜トランジスタとを一画素ごとに対応させて貼り合わされる。変形可能なミラー要素を変形させるために、薄膜トランジスタにより生成される駆動電圧を圧電薄膜に供給する必要がある。このためミラー基板のうちミラー膜構造が形成された面を薄膜トランジスタに対向させ、薄膜トランジスタの電極とミラー膜構造を構成する電極薄膜とを電気的に接続するバンプを介して、両基板が貼り合わされていた。

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【０００４】上記の構成によれば、この変形可能ミラーデバイスにおいては、照明光（入射光）をミラー基板側から入射させる場合、この入射光はシリコン基板に設けられた窓（基板除去部）から入射し、ミラー膜構造で反射され再び窓から射出されることとなる。

【０００５】

【発明が解決しようとする課題】しかしながら、上記従来の変形可能ミラーデバイスでは、シリコン基板に形成された窓（基板除去部）が光を遮ったり、不要な反射を生じさせる原因となるので、光変調のコントラストの低下をもたらすという問題点があった。すなわち、従来の技術では、光の入射および射出がシリコン基板に形成された窓を通して行われていた。シリコン基板は、製造工程における取り扱いが容易になるようにある程度の厚さ（１００μm～２００μm）が必要である。ところが、一画素、すなわち一つの変形可能ミラー要素の大きさを小さくしていくと、窓の開口に比べて窓の深さが深くなってしまう。たとえば、シリコン基板の厚みを１００μm、窓の開口を５０μmとすると、窓の深さは窓の開口の２倍にもなる。

【０００６】本発明はこのような問題点を解決するもので、ミラー膜構造が形成されていた耐熱性基板を能動素子基板と貼り合わせた後に全部除去することにより、光の利用効率が高く、かつ光変調のコントラストが高い変形可能なミラーデバイスを提供することを目的としている。

【０００７】

【課題を解決するための手段】請求項１記載の変形可能ミラーデバイスの製造方法は、耐熱性基板上に第１の電極薄膜層、圧電性を有する圧電薄膜層、および第２の電極薄膜層の順に積層する変形可能ミラー層形成工程と、前記第２の電極薄膜層および前記圧電薄膜層を、画素となる独立したミラー要素形状にエッチングする画素パターン形成工程と、前記画素に対応した能動素子の配列が形成されている能動素子基板において、前記能動素子毎に前記ミラー要素と電気的な接続をとるためのバンプを形成するバンプ形成工程と、各前記ミラー要素とそれに対応する各前記能動素子とを電気的に接続するために、前記バンプと前記第２の電極薄膜層が対向するように前記耐熱性基板と前記能動素子基板を貼り合わせる基板貼り合わせ工程と、前記耐熱性基板を、前記変形可能ミラー層を残して除去する基板除去工程と、を備えていることを特徴とする。

【０００８】上記構成によれば、ミラー要素の光入射側

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に光をさえぎる、あるいは不要な反射を生じさせる構造がないため、入射光を効率良く変調できるという効果を有する。

【0009】請求項2記載の変形可能ミラーデバイスの製造方法は、請求項1記載の変形可能ミラーデバイスの製造方法において、前記耐熱性基板がシリコン基板であることを特徴とする。

【0010】上記構成によれば、エッチングによって前記耐熱性基板を除去できるという効果を有する。

【0011】請求項3記載の変形可能ミラーデバイスの製造方法は、請求項1記載の変形可能ミラーデバイスの製造方法において、前記耐熱性基板が石英基板であることを特徴とする。

【0012】上記構成によれば、エッチングによって前記耐熱性基板を除去できるという効果を有する。

【0013】請求項4記載の変形可能ミラーデバイスの製造方法は、請求項1乃至3のいずれか一項記載の変形可能ミラーデバイスの製造方法において、前記基板除去工程において用いられるエッチング方法が反応性イオンエッチングであることを特徴とする。

【0014】上記構成によれば、耐熱性基板を他の部材に対して選択的にエッチングできるという効果を有する。

【0015】

【発明の実施の形態】以下、本発明の好適な実施の形態に係る変形可能ミラーデバイスの製造方法を添付の図面を参照しながら説明する。

【0016】（第1の実施形態）図1と図2は本発明の変形可能ミラーデバイスの製造方法によて製造される変形可能ミラーデバイス100の一部の断面図である。

【0017】ガラス基板101上に薄膜トランジスタ（以下TFTと略す）102が例えば640素子×480素子の2次元アレイ状に形成されている。TFT102のドレイン電極103には金をメッキした後、所望のパターンにエッチングされたバンプ105が形成されている。バンプ105の高さは20μm程度であり、圧電膜107を挟持する一方の電極薄膜、すなわち画素電極膜106に接続されている。ミラー膜構造は共通電極膜108、圧電膜107、画素電極膜106の積層構造から成っている。共通電極膜108の表面には透明絶縁膜109が形成されている。共通電極膜108、圧電膜107および画素電極膜106の厚みは全部で1μm程度である。

【0018】TFT102によってミラー膜構造の画素電極膜106に電圧が印加されると圧電膜107が変形し、図1の変形しているミラー要素111Aで参照されるように湾曲する。一方、TFT102によって電圧を印加されていない場合には変形していないミラー要素111Bで参照されるように、ミラー膜構造はほぼ平坦となっている。

【0019】共通電極膜108は各画素に対する共通の電極であり、図2に示すようにバンプ201を介して共通電極端子膜200に接続され、共通電極端子膜200の電位によって共通電極膜108の電位が決まる。

【0020】続いて、図3～図5を用いて変形可能ミラーデバイスの製造方法を説明する。

【0021】まず、ミラー膜構造の製造方法を図3を用いて説明する。シリコン（以下S_iと略す）基板300上に、透明絶縁膜109となるS_iの熱酸化膜を形成する。その上に共通電極膜108となるプラチナ（以下Ptと略す）等の金属薄膜を形成する。その上に圧電膜107となるジルコン酸チタン酸鉛（以下PZTと略す）膜を形成する。次に、圧電膜の特性を出すために熱アニーリングを行なう。熱アニーリング工程が必要なので、基板としては耐熱性の基板が必要となる。次に画素電極膜106となるPt等の金属薄膜を形成する。続いて、空間光変調器の画素に対応する独立したミラー要素111を形成するために、画素電極膜106と圧電膜102を所望の画素形状にエッチングする。

【0022】図3では、ミラー要素の形状は円形であり、従って、ミラー要素が変形する領域は円形である。圧電膜に電圧が印加されるとミラー要素は球面状に変形（湾曲）する。TFTとの電気的な接続をとるためのバンプ105は電極パッド301で画素電極膜106と接続される。変形領域をできるだけ円形とするために、電極パッド301とミラー要素の変形領域との間は細いパターンとなっている。なお、一つのミラー要素に一つの薄膜トランジスタが対応して接続されるので、TFTの配列が640×480であればミラー要素の配列の数も640×480となる。

【0023】図4にはTFT素子とミラー要素との接続方法を示す。図3で説明したS_i基板300が、画素電極膜106、圧電膜107および共通電極膜108が形成されている面をTFT102の方に向けて、TFT素子基板のバンプ105に熱圧着される。

【0024】この段階での変形可能ミラーデバイスの一部の断面図を図5（a）に示す。

【0025】続いて、Siを選択的にエッチングできるフッ素系のガスを用いた反応性イオンエッチング法によってS_i基板を全部除去すると、図5（b）に示すようにバンプ105で支えられたミラー膜構造が形成される。なお、Si基板をエッチングする際に、TFTが形成されている基板などエッチングされたくない部分を樹脂などで覆っておいても良い。

【0026】以上のような製造方法の変形例として、ガラス基板上に形成されたTFT素子の代わりに、トランジスタがS_i基板の表面に形成されたS_iトランジスタを能動素子として用い、ミラー膜構造をS_i基板に形成する代わりに石英基板に形成する製造方法を考えることができる。この場合には、ミラー膜構造を変形可能とす

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るために、最終工程において、石英を選択的にエッチングできるフッ素系のガスを用いた反応性イオンエッチングによって、ミラー膜構造が形成されている石英基板を全部除去することになる。この時も、エッチングされたくない部分を樹脂などで覆っておいても良い。

【0027】以上のような工程で製造された変形可能ミラーデバイスを空間光変調器として利用する例を図6に示す。図6は空間光変調器の一部（3要素）だけの断面図である。各ミラー要素に対して遮光ドット611およびマイクロレンズ要素601が共軸に配置されている。遮光ドット611は光を吸収する材料で構成され、透明基板612上に2次元アレイ上に配置されて遮光ドットアレイ610を構成している。マイクロレンズ要素601も2次元アレイ状に配置されマイクロレンズアレイ600を構成している。

【0028】マイクロレンズアレイ600に対して照明光620が照射される。照明光620としては平行光線が望ましい。照明光620はマイクロレンズ要素601によって集光される。変形していないミラー要素111Bにおいて、遮光ドット611がマイクロレンズ要素601の焦点に配置されていれば、照明光は遮光ドット611で遮光されてマイクロレンズの方へは戻らない。一方、変形しているミラー要素111Aにおいて、ミラー膜構造の変形を球面とした場合の曲率中心とマイクロレンズ要素601の焦点とがほぼ一致するようにマイクロレンズ要素の焦点距離が決められていれば、変形しているミラー要素111Aで反射した光は再びマイクロレンズ要素に戻る。マイクロレンズアレイ600、遮光ドットアレイ610およびミラー膜構造は、マイクロレンズ要素601の焦点に遮光ドット611と変形ミラーの曲率中心がほぼ一致するようにお互いの配置が決められる。以上のようにしてミラー膜構造で反射する光を変調することができる。

【0029】なお、ミラー膜構造による光の反射率を向上させるために、透明絶縁膜109の表面にアルミニウム（以下Alと略す）などの反射率の高い材料の薄膜を形成することが望ましい。この際、Alの表面を保護するために透明材料から成る保護薄膜を形成しても良い。なお、透明絶縁膜109は光学的には不要なので、除去して、共通電極膜108の表面にAl薄膜層を形成しても良い。

【0030】本発明の製造方法で製造された変形可能ミラーデバイスは、ミラー膜構造の光入射側に光をさえぎる、あるいは不要な反射を生じさせる構造がないため、入射光を効率良く変調できるという効果を有する。

【0031】図7には、図6に示した空間光変調器を用いた投写型表示装置の主要な光学系の断面図を示す。

【0032】メタルハライドランプなどの光源701から放射された光を放物面鏡であるリフレクタ702で平行性の良い光に変換し、ビームスプリッタ703で空間光変調器の方へ反射させる。図6で説明したように、変形していないミラー要素111Bで反射した光は遮光ドット611で遮光されて投写レンズの方へは行かない。一方、変形しているミラー要素111Aで反射した光は遮光ドット611の周囲を通過してマイクロレンズアレイ600、ビームスプリッタ703を経て投写レンズ704へ到達し、スクリーン705に結像される。このようにして、変形しているミラー要素で反射した光がスクリーンに到達して画像を形成する。

【0033】ここでは一つの空間光変調器を用いた投写型表示装置を説明したが、本発明の製造方法で製造された変形可能ミラーデバイスを備えた空間光変調器は、複数の空間光変調器を用いてカラー画像を投写する表示装置や、レンズを通して空間光変調器に生成された画像の拡大された虚像を観察する表示装置などへの応用が可能である。

【0034】以上、本発明の変形可能ミラーデバイスの製造方法と、その変形可能ミラーデバイスの応用例を説明したが、上記の実施形態で説明した製造方法は、その実施形態に限定されることなく、変形ミラー膜構造を支えていた基板を全部除去するという製造方法に広く適用が可能である。

【0035】

【発明の効果】以上述べたように、ミラー膜構造を支えていた基板を全部除去するという本発明の製造方法で製造された変形可能ミラーデバイスは、ミラー膜構造の光入射側に光をさえぎる、あるいは不要な反射を生じさせる構造がないので、光利用効率の高い空間光変調器を提供できるという効果を有する。

【図面の簡単な説明】

【図1】　本発明の変形可能ミラーデバイスの製造方法によって製造される変形可能ミラーデバイスの一部の断面図。

【図2】　本発明の変形可能ミラーデバイスの製造方法によって製造される変形可能ミラーデバイスの一部の断面図。

【図3】　本発明の変形可能ミラーデバイスの製造方法においてミラー膜構造を製造する工程を説明する図。

【図4】　本発明の変形可能ミラーデバイスの製造方法において、TFT素子とミラー要素との接続方法を説明する図。

【図5】　本発明の変形可能ミラーデバイスの製造方法において、ミラー膜構造を支えていた基板を除去する工程を説明する図。

【図6】　本発明の変形可能ミラーデバイスの製造方法によって製造された変形可能ミラーデバイスの応用例である空間光変調器の構造を示す断面図。

【図7】　本発明の変形可能ミラーデバイスの製造方法によって製造された変形可能ミラーデバイスの応用例である空間光変調器を適用した投写型表示装置の主要な光

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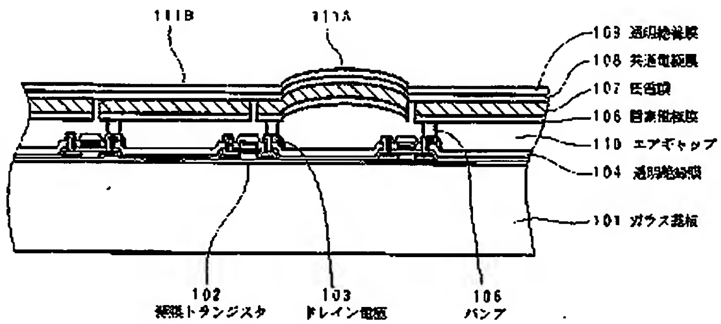
学系の断面図。

【符号の説明】

１００　変形可能ミラーデバイス
１０１　ガラス基板
１０２　薄膜トランジスタ
１０３　ドレイン電極
１０４　透明絶縁膜
１０５、２０１　バンプ
１０６　画素電極膜
１０７　圧電膜
１０８　共通電極膜
１０９　透明絶縁膜
１１０　エアギャップ
１１１　ミラー要素
１１１Ａ　変形しているミラー要素
１１１Ｂ　変形していないミラー要素
２００　共通電極端子膜
＊３００　Ｓｉ基板
３０１　電極パッド
４０１　信号ドライバ回路
４０２　信号線
４０３　走査ドライバ回路
４０４　走査線
６００　マイクロレンズアレイ
６０１　マイクロレンズ要素
６１０　遮光ドットアレイ
６１１　遮光ドット
６１２　透明基板
６２０　照明光
７０１　光源
７０２　リフレクタ
７０３　ビームスプリッタ
７０４　投写レンズ
＊　７０５　スクリーン

【図１】



100 変形可能ミラーデバイス

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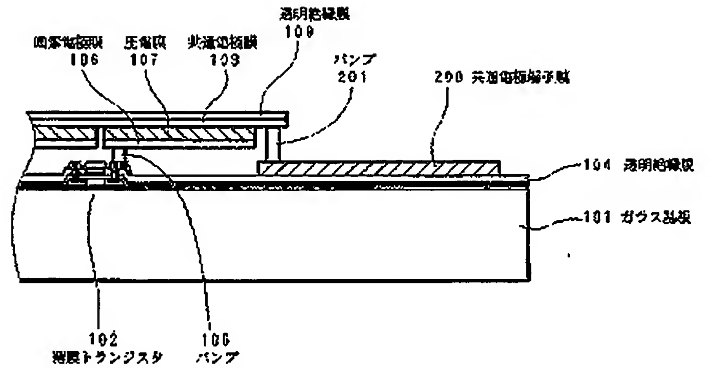
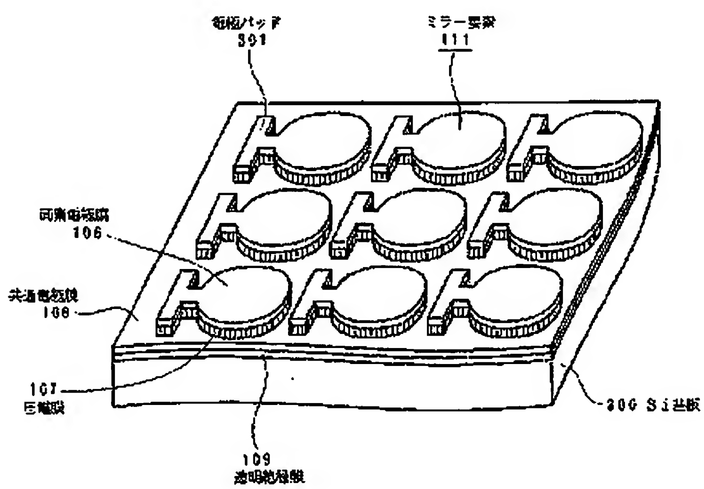
【図2】


透明絶縁膜
109
画素電極膜
106
圧電膜
107
共通電極膜
108
バンプ
201
200 共通電極端子膜
104 透明絶縁膜
101 ガラス基板
102
薄膜トランジスタ
105
バンプ

【図3】


電極パッド
301
ミラー要素
111
画素電極膜
106
共通電極膜
108
107
圧電膜
300 Si基板
109
透明絶縁膜

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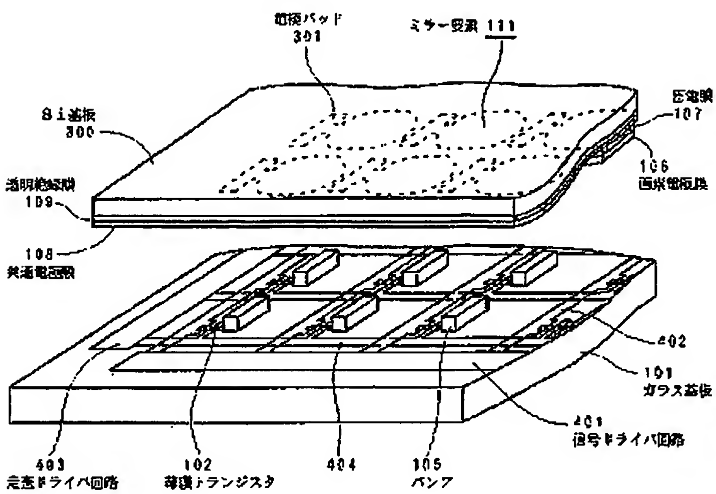
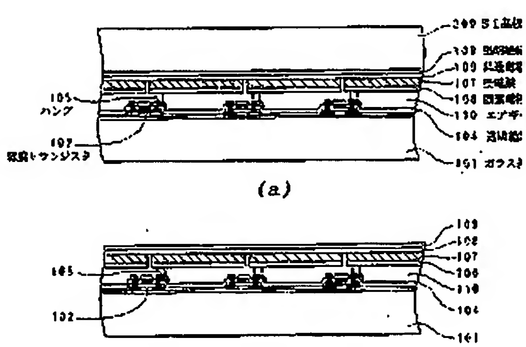
【図4】


電極パッド
301
ミラー要素 111
圧電膜
107
106
画素電極膜
Si基板
300
透明絶縁膜
109
108
共通電極膜
402
101
ガラス基板
401
信号ドライバ回路
403
走査ドライバ回路
102
薄膜トランジスタ
404
105
バンプ

【図5】


109
108
107
106
110
104
101
105
102

(a)　(b)

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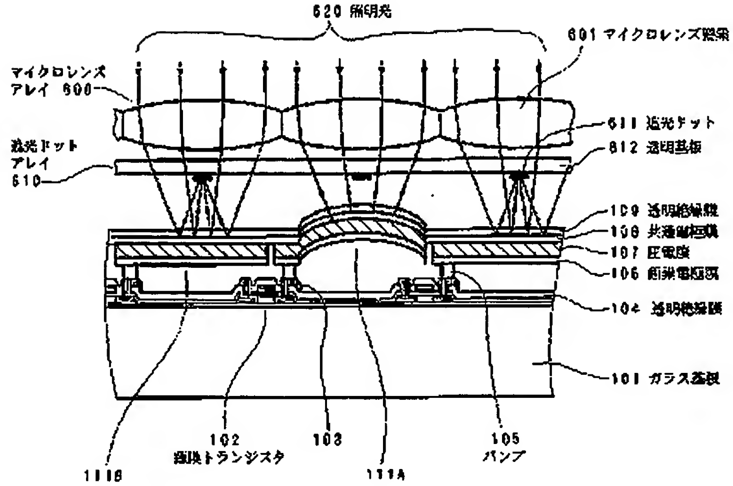
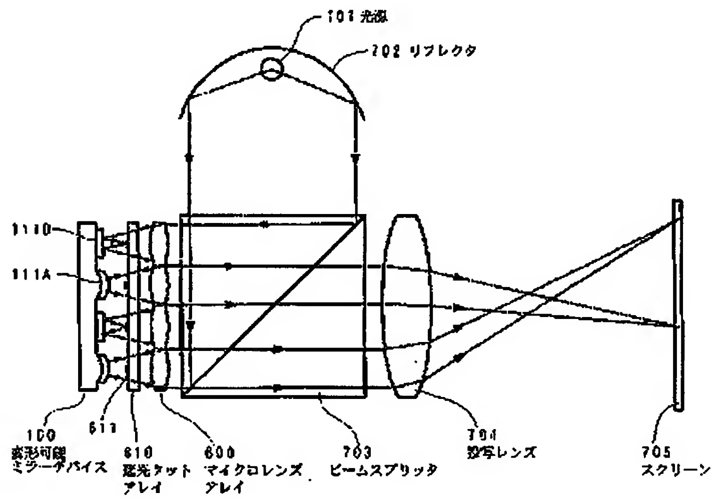
【図6】


620 照明光
601 マイクロレンズ
マイクロレンズ
アレイ 600
遮光ドット
アレイ
610
611 遮光ドット
612 透明基板
109 透明絶縁膜
108 共通電極膜
107 圧電膜
106 個別電極膜
104 透明絶縁膜
101 ガラス基板
102
画素トランジスタ
103
105
バンプ
111B
111A

【図7】


701 光源
702 リフレクタ
111B
111A
100
変形可能
ミラーデバイス
611
610
遮光ドット
アレイ
600
マイクロレンズ
アレイ
703
ビームスプリッタ
704
投写レンズ
705
スクリーン